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ALFALFA IN CULTIVATED ROWS FOR SEED PRODUCTION IN SEMIARID REGIONS.

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ALFALFA IN CULTIVATED ROWS FOR SEED PRODUCTION IN SEMIARID REGIONS.[a]

INTRODUCTION.

The growing of alfalfa in cultivated rows for seed is of more recent origin in this country than is the production of hay by this method. John Spurrier, in a book entitled "The Practical Farmer," published at Wilmington, Del., in 1793, appears to be the first American writer to mention the growing of alfalfa in cultivated rows. The cultivation was designed to retard the development of weeds, which often prove very destructive to broadcasted seedings of alfalfa in the Middle and South Atlantic States. This method is still practiced to a slight extent in a few places in the South, where, however, the climate is too humid for the successful production of alfalfa seed.

[a] From observations made during the summer of 1906 by investigators in this Bureau, including the present authors, it became apparent that the margin between success and failure in profitable alfalfa growing in regions of light rainfall is often so narrow, even when the most drought-resistant strains are used, as to be determined almost wholly by the methods of cultivation employed. Experiments were inaugurated to test the value of various methods of seeding alfalfa, including that of sowing it in rows properly spaced to permit of intertillage.

The results obtained in these preliminary experiments and those secured by practical farmers in the semiarid sections on a field scale indicate clearly that increased yields of seed will follow the use of this method. The value of row seeding and cultivation in hay production is also being investigated. The area seeded to alfalfa is increasing so rapidly that it is not possible to secure enough home-grown seed to supply the demand. As a result, several million pounds of foreign seed of various grades, but often of rather inferior quality, are imported annually.

It is believed that the development of seed production in cultivated rows will go far toward meeting the home demand with a domestic supply and that at the same time a considerable advance in the development of the semiarid sections of the country where farming operations are handicapped by lack of moisture will be brought about. For these reasons it is thought advisable to make the details of this method, so far as they have been developed, available to those now conducting farming operations in those regions of light rainfall where the method promises to give the best results.—B. T. Galloway, *Physiologist and Pathologist, and Chief of Bureau.*

In England as early as 1730, Jethro Tull, the inventor of the drill and the originator of tillage of farm crops in the modern sense, advocated and practiced the growing of alfalfa (lucern) in rows. His teachings first appeared in his "Specimens." Later, in 1829, these were republished by Cobbett in a work entitled "Tull's Horse-Hoeing Husbandry."

What was apparently the first attempt to grow alfalfa for seed in cultivated rows in this country was made by what was then known as the Section of Seed and Plant Introduction of the United States Department of Agriculture. Several contract fields of Turkestan alfalfa were seeded in wide rows in different parts of the Great Plains area in 1903. The poor seeding habits of Turkestan alfalfa when grown in this country, together with the fact that the plants were grown much too thickly in the rows, greatly handicapped the logical development of this method.

The application of the row method of cultivation has been suggested by a number of American experimenters, including Prof. W. J. Spillman,[a] Prof. W. M. Hays,[b] Prof. W. A. Wheeler,[c] Mr. W. M. Jardine,[d] and Mr. C. S. Scofield.[e] Of these only Professor Wheeler has used the method on an experimental and field scale and his results are confirmatory to those presented in this paper.

The work on which the conclusions here presented are based has been conducted at various experiment farms of this Bureau and on the farms of Mr. Lewis Brott, Sextorp, Nebr.; Mr. E. Bartholomew, Stockton, and Dr. W. A. Workman, Ashland, Kans.

Row cultivation for seed growing has been in use for a number of years in the vineyard regions of southern Germany, particularly in Baden and Bavaria, in the production of seed of Alt-Deutsche Fränkische luzerne, a well-recognized German strain. It is said that alfalfa is grown in cultivated rows for seed in parts of Russia, where hand cultivators prove an effective and practical means of holding the weeds in check and of conserving soil moisture.

The method has been employed for a number of years by Dr. L. Trabut, government botanist of Algeria. Fairchild[f] describes a

[a] Annual Report for 1903 of Minnesota State Agricultural Society. 1904.

[b] Hardy Alfalfa in Minnesota. Press Bulletin No. 20, University Experiment Station, Minnesota. 1904.

[c] Forage Plants at the Highmore Substation, 1906. Bulletin No. 101, South Dakota Agricultural Experiment Station. 1907.

[d] Arid Farming Investigations. Bulletin No. 100, Utah Agricultural Experiment Station. 1906. (Issued in 1907.)

[e] Dry Farming in the Great Basin. Bulletin No. 103, Bureau of Plant Industry, U. S. Department of Agriculture. 1907.

[f] Fairchild, David. Cultivation of Wheat in Permanent Alfalfa Fields. Bulletin No. 72, part 1, Bureau of Plant Industry, U. S. Department of Agriculture. 1904.

method of growing wheat between alfalfa rows in Algeria under light rainfall, where it has been found possible to produce a crop of wheat between the wide rows of alfalfa in alternate years. The practical value of this method for the semiarid portions of the United States was indicated in the publication mentioned, without, however, making any direct reference to the seed-producing possibilities of alfalfa sown in cultivated rows under such conditions.

PRINCIPLES UNDERLYING ALFALFA SEED PRODUCTION.

Although alfalfa has been grown increasingly in the West since 1854 or 1855 little has been done to develop a rational seed industry. It is a matter of common observation that even in recognized seed-producing sections the seed crop is very uncertain. A study of some of the factors that cause success or failure has indicated some of the underlying principles affecting the production of profitable seed crops. In Bulletin 118 of this Bureau [a] attention was directed to the fact that cultivated alfalfa is not a homogeneous species, but is composed of numerous races, strains, varieties, and even subspecies. These vary greatly in many characters, and especially in their seed-producing capacity, no pure varieties of known high value comparable with those we have of corn, wheat, and other crops having as yet been established. It has also been noted that the individuals constituting these diverse races, elementary species, or whatever they may be called, exhibit great variation among themselves. This is particularly true of their ability to set seed. To overcome the source of error resulting from this diversity in individual plants the method of vegetative propagation described by Westgate and Oliver,[b] of the Bureau of Plant Industry, has been used in a portion of this work.

It has often been noted that as a rule isolated alfalfa plants set seed far more profusely than those in all but the thinnest stands. Observations on this point have been made in various parts of the Great Plains and intermountain areas and in the farther Southwest. On the Arlington Experimental Farm, near Washington, D. C., an experiment was performed to determine the effect of different degrees of isolation on the seed-setting ability of alfalfa. In this experiment, cuttings from a heavy-seeding plant were rooted in the greenhouse and later set out at varying intervals. Inasmuch as these plants were propagated vegetatively from the same mother plant, they did not show the individual variation mentioned above that

[a] Brand, Charles J. Peruvian Alfalfa: A New Long-Season Variety for the Southwest. Bulletin No. 118, Bureau of Plant Industry, U. S. Department of Agriculture. 1907.

[b] The Application of Vegetative Propagation to Leguminous Forage Plants. Bulletin No. 102, part 4, Bureau of Plant Industry, U. S. Department of Agriculture. 1907.

would have entered into the experiment had seedling plants been utilized.

The plants occupying a space equivalent to a 7-inch square produced a maximum of 38 pods, while those having at their command a space equal to an 11-inch square produced a maximum of 96 pods. The highest number of pods formed on plants grown in rows 39 inches apart and 18 inches apart in the rows was 505.

It will be noted that the yields were in almost direct proportion to the areas occupied. However, it was evident that the plants having the greatest distance between them had not utilized fully their allotted space. This was accounted for by the fact that it was their first season's growth. An adjoining two-year-old cutting from another plant of similar seed-producing tendencies produced 2,080 pods, and this without utilizing all of the space of 18 inches in the 39-inch row assigned to it. Although part of this difference may have been due to inherent capacity, the chief explanation for it must be sought in the firm establishment of the plant and its greater maturity.

Just why the isolation of plants increases the production of seed has not been fully determined, but it is apparent that one of the factors involved is the increased amount of sunlight available to the plant. It has often been observed that trees grown on the banks of irrigation ditches in alfalfa fields or along the margins of fields always interfere with normal seed production as far as the influence of their shade extends. In the course of an experiment on the seed setting of alfalfa it was found that partial shading materially reduced the quantity of seed produced by plants not already receiving more than the optimum amount of sunlight.

When alfalfa plants have sufficient space for full development they have approximately equal illumination on all sides. The effect of this is well shown in figure 1. In this case seed has developed over the entire plant and not at the top only, as is the case in thick stands, where there is more or less competition for the requisite amount of light and air. With the plants so far apart that when fully developed they barely occupy the ground the potential seed-producing surface exposed on an acre is nearly double that of a thick stand. In the latter, because of crowding, the plants are unable to produce seed, apparently on account of shading by closely associated individuals.

In addition to the injurious influence of shade, the crowding of plants interferes with seed production by depriving the plants of sufficient moisture to enable them to mature their seed properly. This, of course, is true only in areas of light rainfall. On the other hand, in sections where irrigation is practiced thick stands by checking evaporation bring about such moist conditions in fields as to

promote unfavorable conditions and so prevent maximum yields of seed.

The basal shoots which usually appear when the plant begins to bloom are developed at the expense of the seed crop. The energy that should be devoted solely to the maturing of the seed is diverted by this new growth. Perhaps the most important factor influencing

FIG. 1.—Heavily seeded isolated alfalfa plant grown near Washington, D. C., where the cimatic conditions are much more unfavorable to the production of alfalfa seed than in the semiarid sections.

the development of these basal shoots which are to form the succeeding crop is the water content of the soil. If the moisture supply be ample, the basal shoots commence their growth about the time the plant comes into bloom. This is disastrous to the seed crop, and for this reason it is necessary that there be a sufficient shortage of mois-

ture at this time to retard or prevent altogether the development of these shoots. In the seed-producing sections of the more humid parts of the Great Plains area profitable crops of alfalfa seed are usually obtained only in the occasional seasons of drought so extreme that the yield of other crops is greatly reduced.

Drought is used here in a qualified sense. There must, of course, be enough moisture in the soil to enable the seed to mature fully; otherwise it will be deficient in germinating power. On the other hand, the soil must not contain enough moisture to force into growth the crown buds that produce the succeeding crop.

The favorable conditions for the production of alfalfa seed which prevail in the semiarid regions are due principally to the presence there of a favorable adjustment of the supply of moisture in the soil to the moisture requirements of the plant when grown for seed. This is especially true when the plants are grown in cultivated rows, as the moisture content of the soil can then be regulated to some degree by proper cultivation.

THE RELATION OF INSECTS TO THE SETTING OF ALFALFA SEED.

Insect visits are essential to the proper pollination of the alfalfa flower. If fertile seed is to be produced in any quantity it is necessary that a certain explosive mechanism within the flower[a] be released. The release of this mechanism, whether it be accomplished by insects or otherwise, is popularly called "tripping."

Experiments and observations[b] both by the writers and by other investigators indicate that practically no seed is produced if the flowers are not tripped. Bumblebees (*Bombus* spp.) are generally believed to be the most efficient of all insects in setting off the explosive mechanism, and hence in bringing about pollination. Honeybees, though not nearly so effective as bumblebees, should not be underrated in this connection. It is a practice in some parts of the country to place beehives along the margins of alfalfa fields intended for seed. Bee keepers follow with their colonies fields planted for seed, for the

[a] By the explosion of an alfalfa flower is meant the snapping out of the stamens and pistil from the wings and keel, which had hitherto enveloped them, to a new position against the standard. This takes place when certain insect visitors insert their nectar-gathering organs into the flower. The impact of the stigma and stamens against the body of the insect appears to have at least three immediate and important results: (1) The wounding of the stigmatic surface of the pistil, making it more susceptible to fertilization; (2) the contact of this sensitive surface with pollen borne on the insect's body from previously visited flowers; and (3) the dusting of new pollen on the insect which will function in pollinating flowers subsequently visited.

[b] The particular investigations in regard to the relation of the tripping of the alfalfa flower to the setting of seed, upon which this is a preliminary report, have been conducted principally by the junior author of this publication.

purpose of getting the honey. This is mutually beneficial, as larger yields of both seed and honey result. Wild bees (*Andrena* spp. and *Megachile* spp.) and various butterflies are also valuable agents in pollinating alfalfa flowers.

That the explosion of alfalfa flowers may be accomplished by other means than insect visitation is quite well known. The insertion of a more or less pointed instrument into the throat of the corolla has often been resorted to in studying the tripping mechanism of individual flowers. Roberts and Freeman [a] describe a method of exploding flowers in large numbers by rolling the head carefully but firmly between the thumb and the first and second fingers. This trips the flowers then at the proper stage of maturity. Tripping on a still more wholesale scale may be done by grasping the entire plant between the hands at successive intervals. In this case it is best to work from the bottom toward the top of the plant, exerting the required pressure at the proper intervals.

It has been found that flowers tripped by any form of manipulation set seed readily, while other flowers left unexploded and from which insects are excluded rarely set seed.

As only a slight pressure on the keel is necessary to trip the flower artificial methods may be resorted to as a means of supplementing the natural process as accomplished by insects. In an experiment at the Arlington Experimental Farm in which the method mentioned of exerting pressure successively over the whole plant was used, the yield of pods was increased 25½ per cent over adjoining rows not thus treated. At Chico, Cal., an increase of 129 per cent in the number of pods resulted. Although greater seed yields also result, two experiments at least indicate that the increase in the number of seeds is not in as high proportion as is the increase in the number of pods.

Further experiments and more exact observations under varying conditions in different sections will be necessary to determine just when sufficiently increased yields of seed may be expected to justify the expense of the undertaking. Any alfalfa seed producer may test this method experimentally on a small scale.

A hundred plants may be counted off and tripped by hand three times a week during the blooming period, using either of the methods previously described. Another hundred plants of similar seeding habits should be left to be exploded by insects. Any greater production of seed on a given number of heads on the manipulated plants as compared with the same number of heads on those not so manipulated may with reasonable safety be attributed to artificial tripping.

If the increased yields which have been obtained in the preliminary experiments are equaled in seed-producing sections, it is prob-

[a] Bulletin No. 151, Kansas Agricultural Experiment Station.

able that means will be devised for exploding the flowers on a large scale. The only sections in which this method will be likely to prove profitable are those where for any reason proper insects are not present in sufficient numbers to explode a large percentage of the flowers.

AREAS TO WHICH THE GROWING OF ALFALFA FOR SEED IN CULTIVATED ROWS IS ADAPTED.

The experiments thus far carried out in the production of seed in cultivated rows have been located principally in the semiarid portions of the Great Plains, in the intermountain area, and in the Palouse country of eastern Washington. The field shown in figure 2

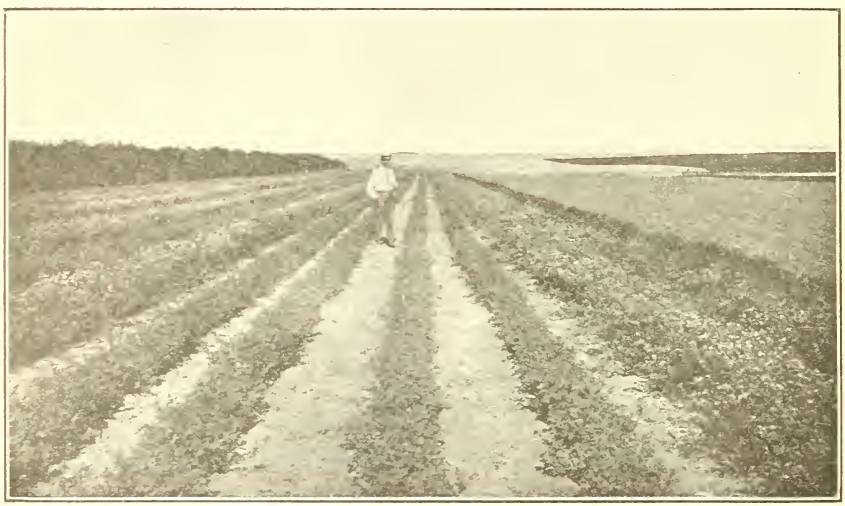

FIG. 2.—Alfalfa in cultivated rows for seed, near Stockton, Kans. In the more mature rows shown at the right and left the first crop was devoted to seed production, while in the rows in the middle of the illustration later growths were left for seed. Photographed July 9, 1908.

is on the farm of Mr. E. Bartholomew, near Stockton, Kans. It is probable that the method will be found to be adapted to many of the semiarid sections of the country which have a rainfall of from 14 to 20 inches, and possibly also to irrigated sections where the supply of water is insufficient for the production of full hay crops. It is also recommended for trial in irrigated sections having water for but half or less of the normal acreage of alfalfa in the district, and also for fields lying slightly higher than the ditch lines but which have the water level moderately near the surface.

Experiments in humid sections indicate that even there row cultivation makes possible much higher yields of seed than are pro-

duced by fields sown broadcast or drilled in the ordinary manner. Figure 1 shows the seed production of an individual plant at the Arlington Experimental Farm, where the average rainfall is 43½ inches. It is doubtful, however, whether even this method will insure the production of paying crops of alfalfa seed under humid conditions.

Row cultivation under conditions of ample rainfall is more valuable as a method of weed control than for increasing seed yields. At the time when pod formation is going on, a certain amount of dry weather and heat is necessary to insure the greatest production of alfalfa seed, even when the plants are isolated. This method promises to be more successful in sections where the annual rainfall is from 14 to 20 inches than elsewhere. Where the precipitation ranges from 20 to 25 inches thin seeding by broadcasting or drilling in the ordinary way may be preferable to row cultivation. Fields sown by either of these methods can be kept up at much less expense. Less frequent cultivation will be necessary, and when needed may be given with an alfalfa renovator or a disk, straight-toothed, or slant-toothed harrow. Under these methods, as in row cultivation, the stand must be very thin if the best results are to be obtained.

SELECTION OF SOIL.

In the semiarid sections the ordinary arable land, such as is used for the common farm crops, will prove well adapted to this work so far as fertility is concerned. Inasmuch as the chief purpose of cultivation is moisture conservation, soils of large moisture-holding capacity should be used when there is opportunity for choice. Care should be taken to avoid fields too alkaline for ordinary crops.

LOCATION OF FIELDS.

In many parts of the semiarid sections alfalfa fields are located in swales or draws or on creek bottoms where the moisture conditions are the best that are available. Where the rainfall is very light it will be safest to utilize such places for growing alfalfa in rows for seed. Where the precipitation is greater or the run-off which the field secures from the surrounding area is sufficient, alfalfa fields, for either seed or hay, may be sown thinly either broadcast or with the drill, thus obviating a large part of the expense of cultivation. It may be safely assumed that alfalfa in cultivated rows will succeed under somewhat drier conditions than fields grown by ordinary methods. In those parts of the semiarid sections where the rainfall is relatively heavy it is probable that even the highest and driest portions of the farm may be successfully utilized by the row method.

PREPARATION OF THE SEED BED.

The preparation of the ground should be such as to rid it as far as possible of weeds and at the same time to provide a seed bed which has become well firmed by settling or rolling, or both. In the drier portions of the semiarid regions summer-fallowing the preceding season may be necessary to provide the soil with the moisture required to insure prompt germination of the seed. This implies keeping the field in the cleanest possible culture during the previous summer. Weeds must be controlled and proper tillage must be given after each rain. The soil mulch thus maintained will check evaporation and in the following year place at the disposal of the young plants the greater part of two years' rainfall.

In the North, where spring planting is advisable, surface tillage must be continued until seeding time. In many cases it will not be necessary to summer-fallow if the field is devoted to a cultivated crop, such as corn, during the preceding year.

In the Great Plains country, when the ground is plowed, immediate harrowing and rolling should follow the plowing. In addition, subsurface packing is advised for all spring-plowed land, but may often be omitted in the case of fall plowing, as natural settling supplemented by harrowing and rolling usually produces a sufficiently firm seed bed. If firming is not done there will be at the bottom of the new furrow a dry, porous stratum of the old topsoil. This condition, which is present in all freshly plowed fields where the surface is dry, may result fatally to the young alfalfa plants, as their roots can not make the necessary development in this layer, containing dry soil, clods, and air spaces. If the field is not to be left fallow long enough for harrowing and natural settling to make the ground sufficiently firm below, this injurious condition should be remedied by subsurface packing with suitable implements. It is necessary that there be sufficient moisture in the soil at seeding time to enable the plant to make a sufficiently rapid growth to permit of surface tillage without covering up the young plants.

The purpose of subsurface packing is not to prevent loss of moisture, but to reestablish the capillary column which was interrupted by the plowing under of the dry topsoil. Unless this is done the moisture from the lower soil can not reach the roots of the plant. Immediate harrowing also prevents considerable loss of moisture from the new topsoil.

In regions where the greater part of the annual rainfall comes during the winter and where the ground does not freeze to a great depth or remain frozen for a long period, as is the case in a large part of the intermountain area and in the southern part of the Great Plains, it may be undesirable to level and firm immediately after

plowing, as is indicated for the middle and northern Great Plains region. This applies only to fall-plowed land. The reason for this is obvious, as both these operations may work against the conservation of the winter precipitation by preventing penetration and promoting run-off. Rough plowed land under the conditions described holds a large portion of the moisture due to rain or melted snow and gives it an opportunity to soak in after each thaw. Spring-plowed fields in the intermountain area and southern Great Plains should be given the treatment previously indicated for similar fields in the colder portions of the Great Plains.

A promising method of securing the desired seed bed, developed by Dr. W. J. Workman, of Ashland, Kans., has been found to give satisfactory results on buffalo-grass sod. The principal difficulty in the growing of alfalfa in cultivated rows for seed is the weediness of the ground during the first season after seeding. This is avoided by the utilization of sod land. A 16-inch sod plow is used to cut a furrow $2\frac{1}{2}$ inches deep through the sod, a stirring plow following immediately in the furrow left by the breaking plow and leaving a furrow about 8 inches deep. On the next round the breaking plow puts the strip of sod in the bottom of the deep preceding furrow, where it is completely covered by the new soil turned up by the stirring plow. The harrow is kept at work to smooth and firm the ground as fast as it is turned, and the alfalfa is seeded with the grain drill while the soil is still moist.

THE PREVENTION OF THE DRIFTING OF SOIL.

If the ground is so sandy as to be in danger of drifting or blowing during high winds, it is the best practice to seed alternate rows of oats or barley and to make these rows run at right angles to the direction of the prevailing winds. The first cultivation of the alfalfa plants will destroy this grain nurse crop, which should in no event be left long enough to injure the young alfalfa plants.

Another method of avoiding the danger of blowing out or drifting in a sandy soil is to sow the alfalfa with a walking garden drill between corn or sorghum rows after the last cultivation. This method has been tried with success under irrigation on the experiment farm conducted by the Office of Western Agricultural Extension near Fallon, Nev. In attempting to use the method under dry-farming conditions careful attention must be given to the supply of moisture available for both plants, and as it has not yet been put into actual practice in the semiarid sections it should first be tested on a small scale.

A third method has been suggested by Dr. H. L. Shantz, of the Office of Alkali and Drought Resistant Plant Breeding Investiga-

tions, Bureau of Plant Industry, which may prove useful when sod land is used. This method consists of leaving narrow strips of virgin sod at suitable intervals through the fields at right angles to the prevailing direction of the most destructive winds.

A method applicable especially to old fields which show a tendency to blow during high winds has been suggested by Mr. N. Schmitz, of the Office of Forage Crop Investigations, Bureau of Plant Industry. This method calls for the seeding of the alfalfa in shallow listed furrows running at right angles to the direction of the prevailing heavy winds. It is necessary that these furrows be shallow, or heavy rains which sometimes occur may bury the seedling plants. If the planting does not take place at the time of listing or if the planting attachment to the lister can not be adapted to this work, a corn drill or check-row planter may be used by making the necessary alterations in the plates, as suggested on page 15. This method of listing may also prove efficient in catching the snow during the winter preceding the planting. Spring harrowing will level the ridges if they are too high at planting time.

CHOICE OF SEED FOR CULTIVATION IN ROWS.

Other things being equal, seed from plants grown without irrigation should be used in preference to any other. The relatively small quantity required when this method is used justifies increased precaution and expense to obtain the best seed available. Some few strains of Turkestan alfalfa have given better yields of hay than the ordinary kind under semiarid conditions. However, none of them have shown satisfactory seed-producing capacity. Special dry-land strains of alfalfa that have been developed through unconscious selection in some of the older dry-farming centers of the West practically always exceed in seed production the Turkestan and all other forms of alfalfa thus far introduced. Whenever these kinds can be secured they should be preferred by the farmer. Seed from the drier parts of western Kansas and Nebraska, from the dry farms of Cache Valley, and from the Levan Ridge near Nephi, Utah, will probably produce the most satisfactory results.

METHOD OF SEEDING IN ROWS.

Several methods have been used in experiments, but the best results have been obtained by sowing seed in rows about 3 feet apart. The distance between rows should be governed by the moisture supply that can be counted on and by the width of the machinery available for use in cultivating. If seeding is done with an ordinary grain drill with shoes 8 inches apart, the stopping up of 4 out of every 5 holes will make the rows 40 inches apart. If, on the other hand, 3 out of

every 4 holes are stopped up, the rows will be 32 inches apart. The wider distance is recommended, especially in sections where the rainfall is very scant.

Another method which has given good results, especially in hay growing, and which may often prove useful where it is proposed to use the same field for both hay and seed production, is that of sowing double instead of single rows. This can be accomplished by leaving 2 holes open and stopping up 3 or 4 holes across the drill. The double rows will then be 8 inches apart, while the space left for intertillage will be 32 or 40 inches wide. Experiments with this method which have been under way for two seasons on the San Antonio Experiment Farm of the Office of Western Agricultural Extension indicate that this method will be useful under some conditions. It has also been used with success under Professor Wheeler's direction on the State substation farm at Highmore, S. Dak.

Any good garden drill will give satisfactory results. If such an implement is not available it may be found advisable to procure one for use in this work.

An ordinary corn drill such as is used in drilling corn in listed furrows can be used by babbitting up the holes in the corn plate and drilling new ones of proper size to drop about 15 alfalfa seeds. If a blank plate is at hand, holes may be drilled into that large enough to drop from 10 to 20 seeds. The germination value of the seed and all factors that tend to lessen the ultimate number of plants must be considered in determining how thickly to seed. The holes should be close enough to drop seeds at intervals of from 8 to 12 inches.

Mr. Lewis Brott, a pioneer dry-land alfalfa seed producer in western Nebraska, has had successful results by using an onion seed plate in a corn drill.

RATE OF SEEDING AND THICKNESS OF STAND.

In mature stands of alfalfa in cultivated rows the plants should average about 1 foot apart in the row. To insure this, it is necessary that the plants be much thicker at first, as their mortality under dry conditions is very high. Satisfactory results have been secured by seeding the alfalfa with an ordinary grain drill so set that it would sow 12 pounds of seed per acre with all the holes in operation. With 4 out of every 5 holes stopped up, approximately $2\frac{2}{5}$ pounds of seed to the acre will be sown.

The stand in a cultivated row need be no thicker even at first than that of the rows in ordinary drilled fields, though the rows of the latter are usually only about 8 inches apart. Where the conditions

are not favorable, it is usually best to seed more thickly at first than is necessary and to thin out the plants subsequently to the desired stand. As much as 7 pounds of seed to the acre have been sown in 36-inch rows without producing too thick a stand for satisfactory results during the first season. This rate of seeding is equivalent to 30 pounds per acre drilled in the usual way under conditions of sufficient moisture with the rows 8 inches apart.

If difficulty is experienced in making the drill feed slowly enough, it may be overcome for the most part by mixing corn chop with the alfalfa seed or by reducing the feed in the grain drill with strips of leather.

Millet or other seed of similar size may be rendered ungerminable by heating thoroughly in an oven for several hours and then mixed with the alfalfa seed to aid in securing any desired rate of seeding. Sawdust and dry soil are also frequently used for this purpose.

It is a very good plan to test the drill first on bare soil with the shoes not touching the ground. In this way it is possible to observe the rate at which the seed is being dropped, and thus a proper regulation of the seeding can be secured. There should be an average of from 4 to 10 plants to the running foot. It has been too often the case that the stand in the row has been too thick for the best development of the individual plants. In such instances cross-harrowing after a majority of the plants have become well established will be found to be very effective in thinning out the stand.

SEEDING IN CHECK ROWS TO PERMIT CROSS-CULTIVATION.

Limited experiments with seeding in check rows indicate that with heavy seed-producing plants of satisfactory character very good yields of seed may be secured with hills 30 inches apart in the row. This distance permits of cross-cultivation, but is rather narrow for most cultivating machinery. The plants being thus isolated on all sides, the production of a maximum seed crop is possible. No practical means have yet been devised for seeding alfalfa in check rows on a large scale. It is probable that an ordinary check-row corn planter can be adapted to this work. It would be necessary to babbitt up the holes in the plate and then rim them out to drop 10 to 20 seeds in a place. The surviving plants can later on be thinned to the best plant in the hill. The portion of the field shown on the right of the picture in figure 2 is sown in check rows. It is possible that alfalfa seeded in rows with a wheat drill could be thinned out to practically uniform distances by cross-cultivation with an ordinary corn plow run at right angles to the rows. The plants, with the exception of a few midway between the two sets of shovels, would thus be destroyed.

TIME OF SEEDING.

Early spring seeding will usually yield the best results, as more favorable moisture conditions for the germination and growth of the young plants are present at this time. However, if the soil can be brought into proper condition of tilth and moisture content, seeding can take place during the late summer if the danger of winterkilling is not too great. In a climate of moderate severity if a 6-inch growth is made during the fall the plants will probably go through the winter safely, and will start out the following spring in much better condition to compete with the weeds than will spring-seeded plants. In semiarid regions it is usually impracticable, however, to seed alfalfa in late summer or early fall owing to the lack of moisture necessary to insure prompt germination.

In the Dakotas and Montana, June seeding will probably give the best results. If seeding is deferred until early summer and the soil is harrowed or otherwise treated to keep it in proper tilth, most of the weed seeds near the surface will germinate. The last cultivation given the land before the alfalfa is sown kills this young growth, thus greatly reducing the trouble with weeds during the first season.

TREATMENT OF THE STAND THE FIRST SEASON.

The well-settled moist seed bed necessary for the growth of alfalfa furnishes ideal conditions for the rapid development of weeds. Several cultivations are necessary to hold even those of the first season in check. A 2-row cultivator provided with narrow shovels is the most practicable machine for this work. Fenders, or, better, a box sled, should be provided to avoid the danger of covering up the young alfalfa plants, and care should be taken to ridge up the rows as little as possible, as this will interfere with mowing operations. After the stand has become firmly established ridging can be readily corrected by cross-harrowing. Mr. Bartholomew has devised a harrow of adjustable width which is very useful both in controlling weeds and keeping up the necessary surface mulch.

The stand may be much thicker during the first season than in subsequent seasons. Some of the plants will be destroyed by cultivation, and the less drought resistant and less hardy plants will be killed by the dryness of the summer and the cold of the first winter. Unless plants are so thick as to crowd one another no thinning should be done by cross-harrowing while the plants are still small.

Experiments in eastern Colorado, eastern Washington, and California indicate that under very dry conditions the plants should not be clipped the first season if they are to make their greatest individual development. On the other hand, in the Willamette Valley of Oregon it has been found necessary to clip during the first season. In any event, clipping, if undertaken at all, should be with the sickle

bar of the mower set high, and probably should not be resorted to unless it is found impossible to hold the weeds in check by the ordinary cultivations. As there is still some uncertainty regarding clipping the first season, it is suggested that farmers leave a portion of the field unclipped to demonstrate the best practice under various conditions. Should the plants begin to set seed, clipping will be advisable. In cases where it is practicable, hand weeding or hoeing may be used to supplement horse cultivation.

TREATMENT OF THE STAND AFTER THE FIRST SEASON.

The treatment of the stand during subsequent seasons will differ very little from that of the first season. The plants should average not more than four to the foot. In the spring or early summer of the second season, if the natural methods of thinning out have not been severe enough it will be necessary to harrow crosswise lightly to accomplish a further reduction in thickness of stand. It may also be worth while to go over the rows with a hoe as soon as the plants commence to set seed, cutting out undesirable individuals. This operation will involve considerable time and expense. However, as there is such great variation in the value of different plants, this procedure may be justified at least until strains of known high value for the conditions at hand have been selected and propagated for use on a field scale.

Row-sown alfalfa fields that have not been properly thinned will not give maximum seed yields on account of the various injurious effects of crowding which have already been discussed.

If it is impracticable to reduce the stand by hoeing or by use of the ordinary harrow it may be done by cross-disking with a disk harrow. The disks should be so adjusted as to cut out the proper number of plants, which will depend, of course, upon their original thickness in the rows.

THE RIGHT CROP TO LEAVE FOR SEED.

Experiments at Stockton, Kans., show clearly that at that place no crop later than the second will yield returns that will be at all satisfactory. Retarded growth during the dry part of the summer defers ripening until so late in the season that cold nights prevent the maturing of the seed. On the other hand, if the first spring growth is devoted to seed production the flowers are likely to become overmature before the best season for seed development arrives. Frequently also, largely on account of the variation in location of the zero point of growth [a] in the different individuals composing any strain, the first spring growth matures very unevenly.

[a] Brand, Charles J. Peruvian Alfalfa: A New Long-Season Variety for the Southwest. Bulletin No. 118, Bureau of Plant Industry, U. S. Department of Agriculture, pp. 8–14. 1907.

For these reasons it is recommended, especially for the Great Plains and the cooler parts of the intermountain area, that the first growth of the second and subsequent years be clipped so early that the time of seed setting will fall in midsummer or slightly later, when favorable conditions are likely to obtain.

The problem as to what crop should be left for seed under the varying conditions of different areas has not yet been fully worked out. It may be well for seed growers to try by simple experiments along this line to get definite information on this point. One row may be given an early clipping and then left to go to seed; another a later clipping, while still another may be left for seed after the first crop has been cut for hay, and so on. The temperature and moisture requirements will largely determine the best practice in this regard, but the necessary presence of suitable insects must not be overlooked.

HARVESTING THE SEED CROP.

The harvesting of alfalfa seed grown in cultivated rows does not differ materially from that in broadcasted fields. The accompanying illustration (fig. 3) shows a bunching device used by Mr. Lewis Brott, of Sextorp, Cheyenne County, Nebr., for dropping the cut plants in

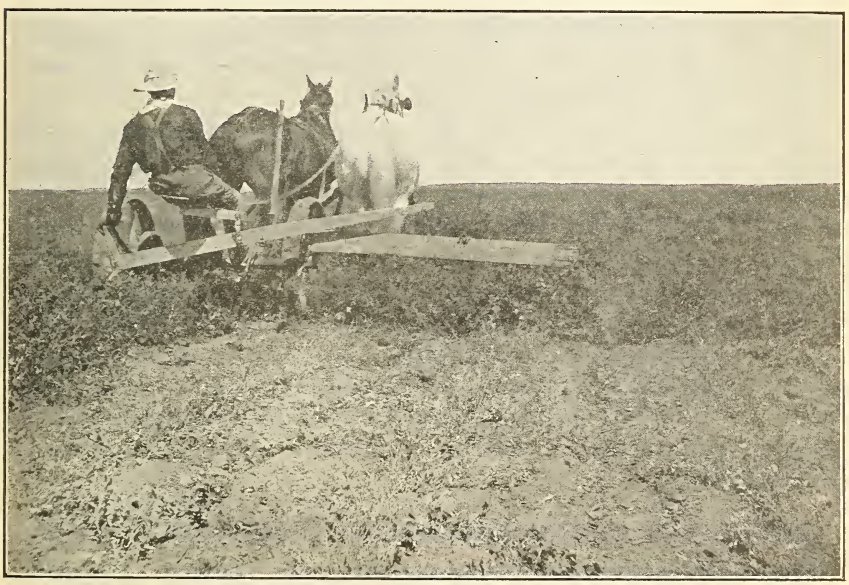

FIG. 3.—Mowing machine with dropper attachment in operation in a field of alfalfa in cultivated rows in western Nebraska. The rows in this case are one-half mile long.

windrows without shattering the pods. The rows in this instance are 36 inches apart and were seeded with a corn drill fitted with an onion seed plate set to drop at 10-inch intervals. With the rows 3 feet apart a mowing machine with a 6-foot cutter bar is necessary if

two rows are to be cut in each swath. This arrangement does away with the necessity of having an extra man to remove the newly cut bunches from the path of the mower at the next round. A mower with a 5-foot cut has been found to be too short to be satisfactory in cutting two rows at once.

It is probable that a center-cut mower with one horse attached at each end of the cutter bar will prove better adapted than even the 6-foot side-draft machine.

In planning to sow alfalfa for seed in cultivated rows the farmer should make his plans from the very beginning with a view to using to the best advantage the available machinery. In adapting the grain drill to secure the proper distance between rows, the mower with which the cutting is to be done must be kept in mind, as well as the cultivators that are to be used in controlling the weeds and keeping up the dust mulch.

Thrashing may be done either from the field or from the stack. The latter method is probably the better, as curing in the stack seems to improve the quality of the seed. The haste necessary in order to keep the machines busy when thrashing is done from the field results in considerable waste. Whichever method is employed in handling the seed crop it is necessary that a tight-bottomed rack be used or there will be much loss of seed. Such a bottom can be secured by the use of matched flooring or by spreading canvas or a tarpaulin over the bottom of an ordinary open rack.

Thrashing may be done in any one of three ways; the regular alfalfa huller, an ordinary grain separator supplied with a hulling attachment, or a grain separator fitted out with alfalfa sieves may be used. The last has been found to give very satisfactory results. Failure to appreciate the fact that the ordinary thrashing machine can be adapted to the thrashing of alfalfa has resulted in the loss of the seed crop on many fields in sections where seed production is not often attempted or, if attempted, is successful only in abnormal years or where it is carried on incidentally to other farming industries. In using the ordinary thrasher it is recommended that the concaves be inverted in addition to inserting the special clover or alfalfa sieves.

POSSIBILITIES OF SEED PRODUCTION IN CULTIVATED ROWS.

Too much must not be expected from the method of growing alfalfa described in these pages. There are large areas in and around the regions to which this method is adapted where no amount of cultivation and isolation of the plants will bring success. On the other hand, there are thousands of acres now lying idle which with intelligent management will yield profitable crops. Maximum or

"bumper" crops must not be expected under the prevailing conditions.

The results obtained in the experiments thus far conducted with this method indicate that it gives especial promise in Utah, in eastern Colorado, and in the western portions of Kansas, Nebraska, and South Dakota. Yields of seed at the rate of 5 bushels to the acre have been obtained. The possibilities of the method when only individual plants of large seeding capacity are used is indicated by the fact that plants removed 30 inches each way from other plants have given yields which if equaled by an acre of such plants at the same distance apart would rival the seed yield produced under the most favorable conditions in the present seed-growing sections.

The method is a comparatively new one and should be tested on its own merits in each area or even in each community. Where reasonable doubt as to its success under given conditions of rainfall, etc., exists, growers should at first devote only a small area, say 2 to 5 acres, to row cultivation, increasing the size of the field if the results justify it.

Seed production under the best conditions is somewhat uncertain. The certainty of profitable yields of hay in most alfalfa-growing sections deters many farmers from letting their fields stand for seed. The light yield of hay procurable under ordinary conditions in the semiarid regions makes the growing of seed a more promising undertaking than in sections where hay production is very profitable. It is probable that under very dry conditions the yield of hay in cultivated rows will also exceed that of a broadcasted stand. Complete data are not yet at hand, but calculated yields per acre based on the weight from a typical rod length of row are given in the accompanying table:

TABLE I.—*Estimated yield of hay and seed to the acre when alfalfa is grown in cultivated rows.*

Variety.	Green weight of hay.	Dry weight of hay.	Weight of seed.
	Pounds.	*Pounds.*	*Pounds.*
Dry-land alfalfa (Brott's)	2,672	1,154	167
Commercial sand lucern (S. P. I. No. 20451)	3,463	1,359	143
Turkestan alfalfa (S. P. I. No. 18751)	2,141	908	62

The yields of hay given in this table are from one cutting obtained on an upland field near Potter, Nebr., sixteen months after seeding. The mean annual rainfall at Kimball, the nearest point for which precipitation records are available, is about 14 inches. In both 1905 and 1906 this mean was exceeded considerably, but in 1907 the total was 15 inches, while up to the end of September, 1908, the record showed

13.85 inches. Mr. Lewis Brott, on whose farm this experiment is under way, secured 150 bushels of seed from a thinly sown, broadcasted field of 50 acres in 1906. This yield was obtained from an old stand.

DEVELOPING VALUABLE STRAINS FOR SEED PRODUCTION.

Experiments under way at the Arlington Experimental Farm, near Washington, D. C., at Pullman, in the eastern part of the State of Washington, and elsewhere tend to prove that heavy-seeding propensity is heritable to a marked degree. In consequence of this, a race of unusual excellence could readily be secured by propagation of the progeny of individuals selected on this basis.[a]

When alfalfa is grown in rows to permit of intertillage, it is much easier to make selections than in broadcasted stands, chiefly because individuals in rows have better opportunity for expression of their normal character. In addition, the comparative isolation of the plants gives readier access to them.

At first thought it might appear that in thinning out stands of row-cultivated alfalfa, only individuals of the greatest seed-producing capacity should be left. A second thought quickly reveals the fallacy of this idea, as the ultimate purpose of all alfalfa growing is hay production. Selection based on seeding habits alone will develop this side of the plant unduly at the expense of its forage-producing capacity. The highest type of alfalfa for use in areas where seed production is the primary purpose in growing the crop is one that combines satisfactory hay and seed producing quality in symmetrical proportions.

It is recommended that the selection of desirable plants commence as soon as the preliminary seeding has developed plants large enough to show their value. The field should be inspected row by row, and seed of the selected plants should be gathered in advance of the regular harvest. The relatively small quantity of seed secured in this way should be sown with great care to make it cover the greatest possible area of ground. The plat of alfalfa thus secured will produce seed of much greater value than that obtained from unselected plants. If this method is carried out, materially increased crops of seed may be secured without detracting from the hay value of the strain. Indeed, both the hay and the seed producing capacity may be increased by the process.

If it is impracticable to secure sufficient seed from selected plants for all of the new seedings that one desires to make, the selected seed

[a] Some progress along this line has already been made by Mr. P. K. Blinn and others. Mr. Blinn, who is in charge of the State substation at Rocky Ford, Colo., has published the results of his investigations in Bulletins Nos. 121 and 128 of the Colorado Agricultural Experiment Station.

should be planted separately, and that harvested from this plat should be used for subsequent seeding. This method will also afford an opportunity for demonstrating the relative value of selected as compared with unselected stock.

CONCLUSION.

The results obtained by farmers on a field scale, as well as of the experiments thus far conducted, indicate that the growing of alfalfa in cultivated rows for seed in the semiarid regions offers every promise of success. The method is recommended particularly for those sections where on account of the light rainfall but one crop, or at best two crops, of alfalfa hay can be secured in each season.

Next to the problem of providing and maintaining a firm, moist seed bed, the controlling of the weeds offers the greatest difficulty. This is especially true during the first season, when their rapid growth makes it difficult to control them by cultivation owing to the danger of covering the small alfalfa plants.

It is expected that the machinery now in use in most communities can be adapted to the growing of seed in rows. While the results indicate that the row method of culture will probably become an efficient factor in the development of the semiarid regions, too much must not be expected of it. Those undertaking the work will be pioneers. To them will fall the task of developing new devices and special adaptations of the implements at hand, upon which will depend in a large measure the practical success of the method.

The alfalfa plant requires but a small supply of moisture when seed setting is going on. Heavy seed crops are to a large extent dependent upon the prevalence during this time of a certain amount of dry weather and heat. In many parts of the semiarid regions an unusually favorable combination of these conditions is present. The power to regulate by surface tillage the supply of soil moisture makes the method of growing alfalfa in cultivated rows for seed of especial promise in those parts of the Great Plains, intermountain area, and other sections where the average annual rainfall ranges from 14 to 20 inches.

Approved:

JAMES WILSON,
Secretary of Agriculture.

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